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Abstract
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The Limits to Environmental Bonds: Lessons from the Labor Literature

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ABSTRACT

Bonds have recently been promoted as an alternative tool for controlling environmental damages, particularly in those instances when the innovative activities of a firm have uncertain future impacts [Costanza and Perrings (1990)]. Under this mechanism, a firm would post a bond ex ante, forfeiting the bond if its activities caused harm to environmental resources. While the benefits of bonds have been developed, there has been little systematic effort to explore their limitations. The labor literature, on the other hand, has extensively studied the limits of bonds as a mechanism for preventing worker shirking. Using the insights found for this parallel problem, this paper explores the limits to environmental bonds, focusing on the problems of moral hazard, liquidity constraints, and legal restrictions. Each limit offers a challenge to the success of environmental bonds. We explore the use of bonds to resolve agricultural nonpoint source pollution problems as a motivating example. We also consider how other incentive schemes suggested by the labor literature might prove useful in the context of environmental management. Specifically, we consider the labor mechanisms of efficiency wages, increasing wage profiles, trusts funds, and rank-order tournaments.

1. INTRODUCTION

Consider this situation: You hire Ole to work around your yard for $2.00 per hour. At this wage and given his disutility from expending effort, Ole has an incentive to shirk on the job. He would prefer wasting time doing unproductive activities like sleeping under a tree because you cannot perfectly monitor his actions. The worst that can happen is that he gets fired and has to find new employment at this low wage. The question you must answer is how can you discipline Ole to prevent shirking. What incentive schemes will increase Ole's costs of malfeasance?

The same basic question underlies the problem of pollution control and environmental enforcement. Despite legal standards for ambient pollution concentrations, a firm has an incentive to shirk on pollution control given its profits derive from a market price that does not reflect social preferences for environmental quality. The regulator's question is how to induce the firm to not shirk on pollution control when behavior is imperfectly monitored. What incentive scheme will eliminate the incentive to shirk?

One suggested solution for both labor and environmental problems is that of an assurance bonding system [see Becker and Stigler (1974), Bohm and Russell (1985), and Perrings (1989)]. A bond is a direct mechanism to induce socially desirable incentives in both workers and firms. In the labor example, Ole would post a bond prior to employment, and then would forfeit the bond if he were caught shirking. The bond increases the costs of shirking, thereby reducing the incentive for malfeasance. The same principle is proposed for environmental control. A firm posts a bond that will be forfeited if pollution control is inadequate.

Yet the question remains as to why bonds are the exception rather than the rule. With few exceptions, even in the labor market, bonds are rarely used [see Carmichael (1989) and Dickens *et al.* (1989)]. Because the labor market is relatively more complete and efficient, why should we expect bonds to be any easier to implement for large-scale, long-term environmental problems? The point is that we should not. Although bonds have been proposed and implemented in the form of deposit-refund systems [see Bohm (1981)], there are limitations to bonds as a solution to any problem of undesirable incentives, and broad environmental problems are no exception. Since the labor literature has identified several key limitations to bonding, our goal is to determine how these limits relate to environmental issues. We employ the lessons learned over the past two decades by researchers in the field of labor economics to consider when bonds may or may not be practical and how bonds can be augmented with other incentive devices for a more effective mechanism to reduce shirking in the environmental workplace.

First, we begin by reviewing the identified benefits of environmental bonds. We briefly consider three of the advantages described in Bohm (1981) and Perrings (1989): (a) efficiency, (b) value registration, and (c) research incentive. Costanza and Perrings (1990) also argue that environmental bonds have benefits beyond reducing shirking. Specifically, it is argued that bonds further encourage the firms to provide information to the regulator by shifting the "burden of proof" of environmental damage from the government to the firm.

Second, we describe the limits to bonding as identified in the labor literature and discuss how they relate to environmental issues. We focus on three key limitations: government moral hazard, liquidity constraints, and legal restrictions on contracting. Government moral hazard exists when the government has an incentive to falsely claim that the firm is shirking, thereby acquiring the value of the bond. Liquidity constraints exist when a firm is forced to post a bond ex ante, thereby restricting entry into the industry since not all firms can acquire the capital necessary for the bond. Imperfect contract enforcement can affect bond performance for a variety of reasons including illegalities, formation defenses, performance excuses, and the inability of the enforcer to do the job. All three limitations offer a challenge to the successful implementation of bonds for environmental management.

Third, to illustrate the potential difficulties with environmental bonds, we explore their use in reducing nonpoint source pollution from agricultural production. Since the significant increases in agricultural production are due in part to the introduction and expanded use of agri-chemicals such as pesticides and fertilizers, this sector provides a useful example. We conclude that the major difficulty with bonds is the liquidity constraints of farmers. These constraints will be binding given the thinness of the insurance market and the fact that debt-to-equity ratios are already high in this sector.

Fourth, we identify other incentive devices suggested by the labor literature to reduce the incentive for shirking. Specifically, we examine the labor concepts of efficiency wages, increasing wage profiles, trust funds, and rank-order tournaments. If solutions can be found to reduce the potential limits to bonds, then we will have increased confidence that bonds can become a useful policy tool for global environmental management. Finally, we offer our conclusions.

2. ADVANTAGES TO ENVIRONMENTAL BONDS

Bonds have been suggested as an instrument to control the external effects from pollution and resource depletion [e.g., Bohm (1981), Bohm and Russell (1985), Perrings (1989), and Costanza and Perrings (1990)]. Environmental bonds originate from the material user fees proposed by Solow (1971) and Mills (1972) where a private entity is required to post a bond covering any potential environmental damages. The goal is for the firm to internalize perceived social costs into its private resource allocation decisions. The value of the bond would be a function of the environmental authority's best estimate of the worst outcome of any specified activity given the current state of knowledge.[1] The bond value would change over time to reflect both practical experience and the results of theoretical and experimental research into innovative activities. Bonds would also insure

[1]Perrings (1989, p. 99) refers to this worst outcome as the "focus loss" of an activity, ". . . describing the least unbelievable conjectural cost."

that the funds exist to indemnify society against the future environmental costs of current activities, with these funding increasing in proportion to the perceived risks. Given uncertain damages, environmental bonds may be an attractive alternative to Pigouvian taxes and quantity constraints.

Perrings (1989, p. 101) suggests a number of advantages to environmental bonds. We focus on three of these: (a) efficiency and the incentive to shirk; (b) value registration, revealing the value placed on the potential damages from the proposed project by the environmental authority; and (c) research incentives and shifting the burden of proof.

2.1. Efficiency and the Incentive to Shirk

Consider the simple analytics of the use of bonds to reduce incentives to shirk. Becker and Stigler (1974) demonstrate that with perfect monitoring the value of the bond, B, should equal or exceed the value of disutility of effort, v. With imperfect monitoring, the value of the bond must reflect both the value of shirking plus the probability of detection, p, such that $pB \geq v$.[2] Any combination of the detection probability and magnitude of the bond should yield the desired result. Therefore, since monitoring expends real resources while posting the bond does not, the seemingly efficient strategy is to reduce the detection probability as low as possible while increasing the value of the bonds as high as possible. This is a classic economic solution to shirking: "hang tax evaders with probability zero" [Kolm (1973)].

Although an infinitesimal detection probability and an infinite bond are unlikely for several reasons outlined in the next section, the message is clear: a firm that requires a worker to post a bond imposes an actual cost for shirking. The worker must take this cost into account when deciding whether or not to shirk while on the job. The result is that the worker will provide the effort that the firm desires.

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[2]See Parsons (1986, pp. 806-807) for additional discussion.

The application of bonds to the environment reflects an identical objective: a government agency requires the firm to post a bond so that any malfeasance will result in the loss of the bond. Firms will now internalize their impacts on social welfare that are unaccounted for in the market price in order to ensure recovery of their bond. There is an increased incentive to provide a socially optimal level of pollution control or safety precautions, given the positive cost for shirking [also see Bohm and Russell (1985)].

2.2. *Value Registration*

Perrings (1989) identifies a series of benefits not addressed in the labor literature. For example, posting the bond would require an explicit registration of the value of potential environmental costs of an activity, opening the issue to public debate and scrutiny. This value registration could then act as a benchmark to guide the environmental costs of future innovative activities. Of course, determining the value of the bond will be a difficult task. If the benefit of bonds is to avoid events of which we are completely ignorant of the damages, then it will challenge researchers in both nonmarket valuation and natural resource accounting. If the value of the bond is unclear, then the firm has significant incentive to play an active role in the process. The firm would find it in its interest to invest resources into either direct research or lobbying activities or both to get the value as low as possible. Explicit value registration will be a confrontation activity.

2.3. *Research Incentive and Shifting the Burden of Proof*

The value of the bond is determined by the potential environmental impact of the firm's activity. If a firm can prove the cost of environmental damages of an activity is less than the cost of their posted bond, then the value of the bond can be reduced. Therefore, Perrings (1989) argues that the firm has an incentive to invest resources in R&D to discover the true value of environmental damages or increase the use of inputs that are more benign to the environment.[3] This incentive is enhanced, according to Costanza and Perrings (1990), by the implied shift in the burden of proof from the public to the firm. Instead of taking the firm to court to prove that the firm was liable for damages, now the firm must prove that no environmental effects occurred. Otherwise, the bond would be forfeited. This not only discourages the firm from shirking, but also encourages it to keep and provide records and to conduct research that would establish the firm's innocence. However, while there are benefits to the additional research and information, it is arguable as to whether this shift in the burden of proof represents an optimal risk sharing strategy. Individual firms are generally viewed as more risk averse than the government, or society as a whole. Shifting the burden of proof from the public to the firm represents a shifting of risk towards a more risk averse segment, rather than away from it.

2.4. *Other Advantages*

A number of additional benefits have been attributed to bonds in either the labor or environmental literature. Perrings (1989), for example, argues for the flexibility of the bonding approach. Specifically, since the bond's value can be adjusted over time, it can reflect increased knowledge about the potential damages from a firm's activity, or diminish as the passage of time proves some of the feared damages to be unfounded. Bohm and Russell (1985) note that bonds also provide firms with an alternative to the production delays that normally result from lengthy governmental testing requirements. By posting a bond, the firm could proceed with its activity, while essentially guaranteeing the outcome of the government tests. Bonds may also be used, as in the labor arena, to reduce turnover, or at least the impact of turnover. Firms leaving an environmentally sensitive industry would not have access to their posted bonds immediately, but would have to wait until the feared damages from their

[3] However, as noted by Perrings (1989, p. 104), ". . . environmental research suffers acutely from the problem of moral hazard. . . . In other words, privately funded research would tend to downplay the environmental costs of innovative activity."

past activities were either proved unfounded or were covered by the bond. This provides an incentive for firms (and their legal successors) to continue to monitor and control the impacts of their past activities, even after leaving an industry. Finally, bonds may appeal in the political arena, since deposit systems for recyclable resources have proven effective throughout the world.

In addition to the basic research incentives provided by bonds (i.e., by reducing the damages associated with an activity, or by proving that fears of such damages are unfounded, the firm may recover the bond early), Perrings (1989, p. 101) argues that a second research benefit exists. "Since the bond would yield interest income, it would generate public research funds in direct proportion to the public concern about the future effects of innovative activities." The problem with this approach, however, is that the bond has been posted as a guarantee, to be returned *in full* to the firm if damages do not in fact occur. By skimming a portion of the bond's interest earnings to fund public research, the firm is being punished ex ante for participating in innovative activities, since a portion of its wealth stream is lost regardless of the future state of the world. The skimming of interest for public research funds reduces the rate of return the firm receives on its bond, presumably below its alternatives in the market place and discouraging investment in this sector. The problem here is similar to the moral hazard problem discussed in section 3 below. In this case, rather than falsely claiming malfeasance and the bond itself, the government would be claiming a portion of its income earning potential with no evidence, or even claim, of malfeasance.

3. IF BONDS ARE SO DESIRABLE, THEN WHY ARE THEY SO RARE?

Despite the numerous advantages claimed for bonds or entrance fees, there are few examples of their use in the real world, either for labor [Carmichael (1989), Dickens *et al.* (1989)] or environmental management [Bohm (1981)]. Their limited use has been attributed in large part to three disadvantages discussed extensively in the labor context: (a) moral hazard, (b) liquidity constraints, and (c) legal restrictions on contracts.

3.1. Moral Hazard

In the labor literature, a major limit to bonding is the fear of firm moral hazard. Shapiro and Stiglitz (1984) argue that the firm has an incentive to capture the worker's bond by simply stating that the worker has shirked. The worker would then be left with the option of challenging the firm or finding new employment. Because legal action is costly, the worker may simply search for new employment. Therefore, unless there is a third party impartial to the proceedings, the worker will have no incentive to work for a firm whose trustworthiness is uncertain [see Carmichael (1985)].

From the public choice viewpoint in the case of environmental bonds, there would be a similar potential for government moral hazard [see Buchanan and Tullock (1975)]. If regulators are interested in maximizing their own private welfare rather than social welfare, then there is a nontrival likelihood that the government could label the firm as a shirker, thereby confiscating the value of the bond. The government is the sole seller of bonds, and the firm has no choice but to either post the bond or not go into business in that country. Firms who want to do business in a country face the risk that the government will unjustifiably take the bond. Appeals to third parties may be ineffective, at best, given the lack of an effective international court.

For example, Rich (1985) notes that the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) of 1980 creates liability without cause. In the case of the United States vs. South Carolina Recycling and Disposal, Inc., the government argued that CERCLA did not require proof that a substance found on a site had been released or threatens to be released from the defendant. Liability is attached to the mere presence of the substance at the site from which other substances were released. These liability rules would create such significant uncertainty with firms that the government could find the firm shirking and confiscate the bond.

Another argument for firm moral hazard is Niskanen's (1971) theory of the bureaucracy. The theory argues that bureaucrats obtain more wealth and power through the expansion of the size and scope of their agencies, achieved by maximizing the agency's budget. If the objective is to maximize the budget, then the agency has a strong incentive to claim the firm has shirked. Once the bond is collected, the agency can use the funds to promote even more stringent environmental controls, thereby increasing the likelihood that more firms will violate environmental standards and will lose their bond.

Mitigating this moral hazard problem is the impact that false bond claims would have on the reputation of the principal in this principal-agent relationship. In the labor literature, cheating imposes a future cost on the firm, as its diminished reputation requires it to pay higher wages [Becker and Stigler (1974)]. Likewise, cheating on the part of the government would reduce social welfare by discouraging innovative activity, requiring an increased rate of return in the sector or a subsidy offered by the government to offset its own cheating. However, there are several reasons to believe that reputation would be a less effective disciplining force in the environmental arena, relative to the labor market. First, the market would be generally thinner, with the number of firms small relative to the size of the bonds being posted. Second, the time horizon on environmental bonds would outlast most government administrations, encouraging current administrations to discount these reputation effects and future administrations to dismiss them as part of the past.[4]

3.2. Liquidity Constraints

The second major factor limiting the use of bonds is liquidity constraints. For labor, workers often do not possess enough capital or cash to post a bond to secure employment. As noted by Dickens *et al.* (1989, p. 338), "workers cannot post bonds with liquid assets they do not have." Eaton

[4]There is also the potential for firm moral hazard. If the firm realizes its damage exceeds the bond, then they have an incentive to shirk. The bond is no longer an effective threat to reduce shirking.

and White (1982) demonstrate that even with perfect capital markets in which the worker could borrow the bond, the possibility of worker default still prevents a bond from effectively inducing the optimal level of effort. They also show that if workers differ by wealth, then the firm will find it in its interest to discriminate, only employing the richest workers.

Liquidity constraints also apply to environmental bonds, perhaps even more strictly. When confronting potential environmental damages, the costs may well go as high as hundreds of millions of dollars. Requiring a firm to post a bond of this magnitude will severely constrain its assets. The larger the bond required, the greater the probability that a firm will have insufficient liquid assets to deposit up front. If the firm cannot post the bond, then the project might be dropped even though, from the ex post social welfare viewpoint, the initiative may be beneficial. In contrast to Costanza and Perrings' (1990) argument that bonds are "minimally intrusive into the internal operations of the regulated firm" (p. 72), we contend that liquidity constraints will be binding in many instances, affecting both the possibility of default and borrowing ability of the firm.

Costanza and Perrings' (1990) optimism rests on the assumption that capital markets will develop so that the firm can risk-pool by insuring against the bond. A possible solution is for insurance markets to develop to spread the risk of the firm defaulting on borrowed assets used to post the bond. In labor markets, such insurance markets do exist to insure against employee dishonesty [see Botnick (1983) for details]. The size of bonds needed for labor relative to those for environmental issues, however, suggest that insurance markets will bear a significantly higher risk of a major multibillion dollar claim. The cost of a policy backing an environmental bond will be significant, thereby increasing the possibility of default.

Default has created a dilemma for insurance firms who have attempted to insure firms from environmental litigation. Rich (1985) stresses that recent developments in environmental litigation are causing a "wholesale retreat" from the environment liability market. Pollution insurance has become increasingly scarce over the past decade due to insurers' inability to properly underwrite environmental liability. Rich notes that regulations such as CERCLA create retroactive and nearly absolute liability and impose joint and several liability [also see Tietenberg (1989)]. These changes in liability have created a climate of such uncertainty that insurance companies are unlikely to respond immediately to the call to back environmental bonds. Because litigation costs for CERCLA range from $3.5 to $6.4 billion for the 1,800 National Priority List sites, insurers will be extremely cautious about liability for environmental hazards [see Rich (1985, p. 41)].

Other problems with the insurance market include the classic example of adverse selection, which exists when those firm who are most likely to forfeit search out the insurer or a banker. A self-selection bias exists such that the insurer or banker may perceive only untrustworthy firms enter the market [see Akerlof (1970)]. Weiss (1990, p. 9) outlines why bankers would be reluctant to give loans to finance bonds under adverse selection. A firm wanting to borrow funds for the bond takes into account both the market price and the probability of not being caught shirking by the government. Bonds financed by the bank encourage firms to enter markets or undertake innovations where the probability of successful shirking is low, but the reward for success is high. This arises because the firm only fully pays the borrowed bond if successful. Therefore, the firm can reduce its expected cost of the bond by entering low success probability markets. Bankers would recognize the firm's incentive and would, therefore, not lend funds for the bond.

If private insurers do not create the market necessary to reduce liquidity constraints, then some other institution must be developed. The obvious institution is some form of government insurance agency. A firm would then have access to capital to post the bond by borrowing or insuring through the government. Government insurance institutions, however, have not always been effective. The bailout of the savings and loan industry is one recent example. Other possibilities include group coverage or self-insurance schemes, both of which are complex, but potential, institutional frameworks to overcome liquidity constraints to environmental bonds [see Faron (1985)].

Another indirect effect of liquidity is that even if the assets for bonds could be borrowed, the firm now has less borrowing capacity for other essential capital. New capital for production or research will be restricted if the firm has used a potentially large fraction of borrowing capacity to post the bond. This indirect effect will constrain the overall development of the firm, which may not be beneficial from a social welfare viewpoint.

Bohm (1981, p. 125) provides some evidence that liquidity constraints may not be such a problem as we have suggested. The Swedish government required Swedish charter companies to post a bond of 50,000 SEK (1972 value) to be used to compensate customers in case a trip was unexpectedly canceled. Bohm notes that even with the bond the industry more than doubled in size from 57 firms in 1972 to 130 firms in 1978. Given the relatively small bond and the significant increase in leisure demand, the bond was not a barrier to entry. If we are considering firms where the potential environmental costs are in the multimillions, however, then the bond should pose a more significant barrier. We can only speculate at this point, but given the insurance industry's retreat from the environmental liability market, such large values may create a significant challenge to the use of bonds as an efficient incentive mechanism.

3.3. Legal Restrictions on Contracts

A bond is a contract between the firm and the worker or the government and the firm. If the contract is breached by shirking or lax pollution control, then the worker or firm will forfeit the bond. Given perfect enforcement of the contract, the bond will efficiently achieve the goal of socially desirable work effort or pollution control. However, contracts are imperfectly enforced. Illegality, enforcer sloth, formation defenses, and performance excuses all provide an avenue for the worker or firm to challenge the loss of a bond for shirking. The labor literature recognizes the limits of bonds due to legal restrictions on contracts. Dickens *et al.* (1989) point out that confiscating a bond may be viewed by the courts as an unfair penalty. This is especially true if the bond is set high relative to damages in order to reduce monitoring expenses. A loss of this bond would be seen as a super-compensatory damage award. Recognizing that imperfect enforcement is a fact, the worker's cost of shirking may seem lower because he/she can challenge the firm's authority to confiscate the bond. The incentive of the bond is diminished, thereby limiting its effectiveness in inducing optimal effort levels.

Imperfect contractual enforcement also exists for environmental bonds. If the government claims the firm has shirked on pollution control, then the firm has a strong incentive to challenge the loss of the bond. We consider two main attacks the firm could use: performance excuses and formation defenses. See Posner (1986) or Cooter and Ulen (1988) for complete discussions of imperfect enforcement of contracts.

Suppose a firm has its bond confiscated due to a perceived failure to adequately control pollution. The firm could argue that forces or acts of God beyond its control, which were not explicitly outlined in the contract, caused their failure. Natural catastrophes, including earthquakes or floods, provide a performance excuse for the firm if the terms of the contract are now physically impossible to fulfill. The firm may also argue that changes in the environment destroy the purpose of the contract, thereby limiting the usefulness of the bond to deter shirking.

If a performance excuse fails, then the firm can turn to a formation defense. A formation defense is used when there are perceived imperfections in the procedures to define the contract. Imperfections include incompetence, unilateral or mutual mistake, misrepresentation, and unconscionability. The firm could challenge the loss of the bond by arguing that the monitoring agency was incompetent in forming the value registration of the bond. The accuracy of measures of nonmarket values may prove a point of contention if the firm challenges the competence of the investigators assigning values. Mistakes or misunderstandings offer the firm an opportunity to recapture their bond. If the details of the contract do not specify all contingencies, then the chance increases that the firm will successfully argue that it misunderstood ambiguous clauses. Misrepresentation excuses occur if the government has withheld information or has misrepresented the damages associated with shirking. If the government's objective is to seek rents by setting rents, then overstating damages will force the firm to post too large a bond. Finally, if all else fails, the firm could appeal to the doctrine of unconscionability. Unconscionability is a vague, shadowy area that steps beyond the traditional definitions of duress to include threats, bargaining incompetence, and asymmetric information.

Legal restrictions due to both performance excuses and formation defenses limit the effectiveness of environmental bonds. A firm can always challenge the loss of a bond. This gives firms strong incentive to allocate resources to a legal war chest to challenge or stall government procedures [see Kambhu (1990)]. Resource that could be used more productively will be used in costly legal battles. To illustrate the legal costs associated with environmental hazard, we again need only consider CERCLA. Rich (1985) estimates litigation costs will exceed $8 billion in battles over liability of superfund sites, 79 percent of which will be paid by private firms. Yandle (1988) notes that the resources spent on litigation could clear up another 400 superfund sites. The threat of imperfect enforcement of a contract can significantly reduce the efficiency of the environmental bond.

4. SHOULD FARMERS PAY ENVIRONMENTAL BONDS?

Including the conservation titles in the Food Security Act of 1985 signaled an important turning point for agriculture and natural resource policy in the United States. The conservation reserve, conservation compliance, sodbuster, and swampbuster provisions tied resource management to agriculture commodity titles and significant budget allocations for coordinating agriculture and environmental policy. These and related environmental provisions are continued in the Food, Agriculture, Conservation, and Trade Act of 1990 and the current President's Water Quality Initiatives. From these initiatives it is clear that future agriculture legislation in the United States will have important conservation and environmental content and that these measures will directly and indirectly influence the performance of the agricultural sector. In order to better understand the impact of coordinating agricultural and environmental policies, we evaluate the implications of using bonds to resolve environmental problems associated with agriculture.

A major form of pollution associated with the agricultural sector is the use of agri-chemicals. In the past four decades, government programs have promoted and subsidized increased pesticide and nutrient use [see Quigley (1967) and Reichelderfer and Hinkle (1989)]. Between 1964 and 1986, the U. S. Department of Agriculture (1985) estimates that pesticide use has tripled. In 1982, more than 90 percent of U.S. row crop acreage was treated with herbicides. Chesters and Schierow (1985) estimate that about 70 percent of nutrients reaching waterways originate from agricultural lands.

The other major impacts of agriculture on water arises from erosion and sedimentation. Phipps and Crosson (1986) note that the capacity of lakes, irrigation channels and drainage ditches have declined due to the deposition of eroded soil. An estimated 1.4 to 1.5 million acre-feet of reservoir and lake capacity is permanently filled each year with sediment [Dendy (1986)]. Clarke *et al.* (1985) contend that the annual costs of off-farm damage from sedimentation, ignoring biological effects, ranges from $4.2 billion to $16.9 billion (1985 dollars).[5]

Reducing chemical use, erosion, and sedimentation poses significant problems to the environmental manager. Are environmental bonds a solution to the agricultural sector's nonpoint source pollution problems? Not likely, due to the liquidity constraints that currently exist in the sector. The USDA estimates that 21 percent of all farmers already have a debt-to-equity ratio exceeding 40

[5]Salinization and waterlogging are also associated with agricultural production. See Young and Horner (1986).

percent--a ratio considered high enough to cause severe financial stress [see Johnson *et al.* (1986)]. Harl (1986) has noted that financial stress has increased to the extent that the frequency of farm foreclosures, forfeitures on land contracts, and defaults on notes have reached levels not seen since the Great Depression. In fact, from 1982 to 1986, the U. S. government paid $8 billion to farmers through commodity programs, more than 31 percent of net farm income [USDA (1986)]. Because producers are already receiving subsidies to maintain farm income, introducing an additional lump sum bond payment is probably infeasible.

In addition, producers often take short-term loans before planting season. The bond will require farm operators to trade off loans for current production with loans to finance the bond. Each producer has a limit to its borrowing capacity, and imposing an additional constraint from the bond may well drive the small operators with limited equity out of business. This can lead to an even more concentrated industry.

The possibility of environmental insurance markets coming into existence as a solution to liquidity constraints is low due to the uncertainty involved in the agricultural sector. Because producers depend on weather, there is no guarantee that the producer can meet the monthly premiums to secure coverage. Therefore, private insurers will be hesitant to enter the market. Although farmers may purchase crop insurance, many have not. Because the federal disaster relief payments enacted in 1988 and 1989, which covered up to $100,000 of losses, other insurance sellers will find few buyers [see Kennedy and Visser (1990)]. The government could reverse the insurance so that instead of farm disaster, they would insure against environmental disaster from the farm. This would then make the government the safety net for damages both to agriculture and from agriculture.

Another solution to eliminate liquidity constraints is to secure the bond by a lean on the nondepreciable assets of the farm. Since there would be no up-front payment, the farmers would not be directly bound by their liquid assets. They would be bound, however, by the fact that the value of their nondepreciable assets might not cover the potential environmental damage. This is especially a problem in agriculture, since the monitoring and assigning damages will be difficult. Generally, it is the cumulative effect of numerous agricultural products that creates environmental problems. The nonpoint source nature of agriculture-induced pollution makes it difficult to estimate the effect of an individual producer on environmental quality [see Cabe and Herriges (1992)]. Who should be punished, if the damage is due to a collective of producers, is an issue that advocates of environmental bonds need to address.

Liquidity constraints are the major factor that reduces the attractiveness of using environmental bonds in the agricultural sector. Farmers work from a small profit margin and the requirement that they post substantial funds up front will have a significant impact on the sector. Neither private bankers nor insurers will step up quickly to offer the financial backing necessary to unbind the constraint. This result is similar to the labor problem where workers rarely have the private assets to post a performance bond. In the next section, we consider whether the labor literature has other alternatives to reducing shirking, and whether these other schemes might work in agriculture.

5. OTHER INCENTIVE SCHEMES OFFERED BY THE LABOR LITERATURE

Faced with the apparent rejection of bonding in real labor markets, the labor literature has developed a series of alternatives to bonds, both as theoretical enforcement constructs and as means of explaining stylized characteristics of the labor industry (e.g., pensions, hierarchical wage structures, and mandatory retirement). Given the parallels between the labor and environmental shirking problems, the question naturally arises as to whether market forces in the labor industry have developed tools that have a place in environmental management as well. In this section, we explore four labor enforcement mechanisms: (a) efficiency wages, (b) increasing wage profiles, (c) trust funds, and (d) rank-order tournaments.

5.1. Efficiency Wages

Efficiency wage models have received considerable attention in the labor literature, initially as an explanation of involuntary unemployment in developing countries [Liebenstein (1957)] and later as a mechanism for firms to reduce worker shirking, to lower turnover rates, and to improve the quality and performance of workers.[6] The concept of efficiency wages is a simple one, based on the notion that the level of effort (or efficiency) of the worker will depend upon the real wage he or she receives. By offering workers a wage in excess of the "market clearing" wage, the firm increases its hourly wage costs, but this is offset by the increased productivity of the worker. In the case of Ole, our hired hand from the introduction, we increase the chances that our lawn will in fact be mowed by offering him $3 an hour instead of $2. The increased wage improves his morale, his attitude towards us as an employer and his opportunity costs of shirking.[7] If he fails to work and is caught, he may only be able to find work at the lower wage (i.e., in the "secondary market").

Efficiency wages are not new to environmental economics, but rather than taking the form of an implicit contract, they have been developed as an explicit contract in the form of Pigouvian subsidies.[8] Firms that shirk, by damaging the environment, are forced into a secondary market where

[6]The literature on efficiency wages is extensive, including Akerlof (1982,1984), Shapiro and Stiglitz (1984), Calvo and Wellisz (1979), Malcolmson (1984) and Salop (1979). Reviews of the literature can be found in Akerlof and Yellen (1986), Yellen (1984), Weiss (1990) and Parsons (1986). See Lindbeck and Snower (1988) for an alternative view.

[7]There are several reasons for this linkage between wages and worker productivity, which Weiss (1990) categorizes into direct and indirect effects. The direct effects arise due to the impact of real wages on the health of the worker [Liebenstein (1957)]. Ole will not, or cannot, work hard if our $2 wage does not provide for a sufficient level of nutrition and health care. Indirect effects can arise due to the impact that wages can have on the worker's sense of morale and firm loyalty. Akerlof (1982, 1984), for example, explains efficiency wages as a partial gift exchange between the worker and the firm, with the firm providing higher wages in exchange for the worker's gift of loyalty and effort in excess of minimum effort levels.

[8]Klein and Leffler (1981) identify a "price premium" that could be used as a means of guaranteeing contractual performance. This premium is to compensate the buyer or seller who invests in capital that is specific to a transaction. For example, utilities invest in coal-fired generators that

they earn only the market rate of return on their investments. In this context, Pigouvian taxes can be thought of as a negative efficiency wage. In the labor field, this would correspond with paying individuals their marginal value product in the primary industry, but having the ability to garner a portion of their wages should they quit and become employed in the secondary labor market. Finally, implicit efficiency wages, similar to Akerlof's (1982, 1984) "gift exchange," may also exist in the environmental arena, with the firm tacitly exchanging additional effort in pollution control for government leniency regarding pollution control standards at a future date.[9]

In agriculture, commodity and price supports could be considered an efficiency wage. If price supports were coupled with environmental performance, then shirking could result in a significant penalty. The total level of support for a crop is determined mainly by the target price--the minimum income support on all eligible production. The farmer receives a deficiency payment that equals the difference between the target price and the average market price (or loan rate). Loss of this income support could be used as a penalty due to shirking on environmental protection. This penalty, in fact, exists with the enactment of the 1985 Food Security Act. Both the sodbuster (producing on highly erodible land) and the swampbuster (converting wetlands to farm use) provisions specify the penalty of shirking as denied access to government programs, including price and income supports. With the current President's 1990 Water Quality Initiative, this penalty could be extended beyond erosion and wetlands to also include water contamination by agri-chemical use.

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require a specific coal for maximum thermal efficiency [Kerkvliet and Shogren (1992)]. Whether this price premium could be used on a sustained basis to make environmental-specific technology more attractive is open for debate.

[9]While verification of such tacit agreements is difficult, explicit versions of this type of gift exchange can be seen in the Clean Air Act Amendments of the 1990. For example, firms that reduce toxic air pollution emission early, by 90 percent or more, are given six additional years to meet the corresponding MACT standards [Wegman (1991)].

5.2. *Increasing Wage Profiles*

Lazear (1979, 1981) provides an alternative to assurance bonds that avoids the liquidity constraint problem, while retaining an incentive for workers to abstain from shirking. Under increasing (or life cycle) wage profiles, workers are initially paid less than their value marginal product (VMP). This deficiency is made up over time as the worker's wage is gradually increased to beyond their VMP. As noted by Carmichael (1989), this is essentially an installment plan version of assurance bonding. Early in their careers, workers contribute to a fund that will later return them wages beyond their VMP. They are reluctant to shirk during their careers, for fear of losing this investment. In return, firms can offer wage streams with high discounted present value due to the increase in productivity.

The environmental counterpart to an increasing wage profile would involve a combination of taxes and subsidies. Firms would initially pay taxes into an environmental incentive fund. Over a fixed time period, these taxes would be gradually converted into a subsidy, paying the firm back the fund's principal and interest. Unfortunately, while this mechanism provides firms with some incentive to avoid shirking, it will not be completely effective. As pointed out by Akerlof and Katz (1989) in the labor context, workers will have greater incentive to shirk early on in their careers, when their contributions to the installment bond fund have been small, and hence the cost of shirking and being caught is small. In fact, Akerlof and Katz (1989) demonstrate that the wage profiles concept will only work if they take the extreme form of a trust fund, with workers paid a flat wage during their entire career, with a guaranteed bonus or pension upon retirement. This leads naturally to the consideration of labor, and environmental, trusts.

5.3. *Trust Funds*

One solution to the liquidity constraint problem in the labor market is to have the firm post the assurance bond, rather than the worker. In essence, this vests the initial "property right" of shirking to the worker, rather than with the firms. It is not surprising then to find that Akerlof and Katz's (1989) optimal trust equals v/p when workers are risk neutral and the discount rate is zero.[10] This is exactly size of the optimal up-front bond. The initial costs have just been transferred to the firm. In a like manner, government agencies could encourage pollution abatement efforts by establishing environmental trusts for existing firms. If damages occur prior to a specified time period, the trust would be drawn down to cover these costs. At the end of the period, the firms could claim the remainder of the trust. Firms would have an incentive to avoid environmental damages in order to maintain the value of the trust, just as they would with an up-front bond. Again, the cross-compliance provisions in recent farm bills can be viewed as short-term trusts. Farmers are given access to commodity programs if they meet specified environmental constraints. One limit to the trust approach, of course, is that governments also face liquidity, or at least budget, constraints. In addition, there is the risk that the practice of establishing environmental trusts would encourage new firms to enter an industry and exaggerate their potential for damage to the environment, just to gain access to the trust system.[11]

5.4. Rank-Order Tournaments

While both wage profiles and trust funds provide alternatives to assurance bonding that reduce the liquidity constraint problem, neither addresses the moral hazard problem of the principal in this principal-agent problem. In the case of increasing wage profiles, the firm would have an incentive to falsely claim malfeasance once the worker's wage exceeded his marginal value product, whereas he would wait until just before retirement under a trust system. Similar problems would arise in the application of these policy tools to environmental management.

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[10]Recall that v equals the value of the disutility of effort and p denotes the probability of being caught shirking.

[11]A similar argument has been raised against the use of subsidies, versus taxes, in controlling pollution problems. See, for example, Downing (1984, p. 181).

Rank-order tournaments, initially developed by Lazear and Rosen (1981), avoid the principal's moral hazard problem by precommitting her to a fixed budget outlay. The multiple agents are discouraged from shirking by tying the total reward to their final performance ranking. For example, in a single-period labor market model, firms would commit to paying a fixed percentage (P) of the workers a high wage (W), while the remaining workers would receive a lower wage (w). The firm is assumed to be able to observe each worker's productivity only with error.[12] They have an incentive to award the higher wage to the most productive workers in order to encourage production, with no associate incentive to cheat, since it would not alter their total wage bill. Workers are encouraged to work in order to receive the higher wage.[13] The level of shirking is controlled by altering the spread between W and w and the probability of "promotion" to the high wage. The risk is, of course, that the workers will collude, providing a lower level of overall output for the same level of compensation. This risk is perhaps greater in environmental management problems, due to the thinness of the market, than in labor markets, where the number of workers can reduce the opportunities for collusion.

In the environmental arena, the rank-order tournament is similar in nature to Xepapadeas' (1991) random penalty (or reward) mechanism. In the latter case, the regulatory agency randomly penalizes a firm or subset of firms in a region if pollution levels exceed its chosen standard. The individual firm has an incentive to reduce its pollution level in order to reduce the overall pollution level and avoid the chance that it will be selected for the penalty. The random assignment of the penalty avoids the need for the regulator to monitor firms individually. The rank-order tournament, in contrast, does require some firm-specific monitoring, in order to conduct the ranking. However, it

[12]Typically, this error is assumed to have two parts, one worker-specific and the other common to all workers. These would have natural counterparts in an environmental setting, with the individual error corresponding to unobserved firm specific effort (or shirking) and the joint error corresponding with random environmental events. such as weather, that influence the overall level of environmental damage.

[13]Note here that rank-order tournaments are a rank trust.

replaces the uncertainty of the random penalty with the firm's own uncertainty regarding its relative position in the industry. Additional research is needed to compare the relative merits of these two enforcement mechanisms.

6. CONCLUSIONS

Our purpose has been to consider the use of environmental bonds, while considering the lessons from the labor literature. While limits such as government moral hazard, liquidity constraints, and legal restrictions pose a challenge to bonds, labor economists have proposed several useful alternatives including efficiency wages, increasing wage profiles, trusts, and rank-order tournaments. More effort needs to be devoted to understanding how these alternative incentive mechanisms can be translated into environmental management tools. We offer only the basic structure in this paper. Our next step is to develop the analytical framework to systematically evaluate the applicability of these tools for improved environmental policy.

7. REFERENCES

Akerlof, G., 1970. The market for lemons: quality uncertainty and the market mechanism. Quarterly Journal of Economics, **84**(3): 488-500.

Akerlof, G., 1982. Labor contracts as partial gift exchange. Quarterly Journal of Economics, **97**: 543-569.

Akerlof, G., 1984. Gift exchange and efficiency-wage theory: four views. AEA Papers and Proceedings, **74**: 79-84.

Akerlof, G. A., and L. Katz, 1989. Workers' trust funds and the logic of wage profiles. Quarterly Journal of Economics, **104**: 525-536.

Akerlof, G., and J. Yellen, 1986. Efficiency Wage Models of Labor Market. Cambridge University Press, Cambridge.

Becker, S., and G. Stigler, 1974. Law enforcement, malfeasance, and compensation of enforcers. Journal of Legal Studies, **3**(Jan): 1-18.

Bohm, P., 1981. Deposit-Refund Systems: Theory and Applications to Environmental, Conservation, and Consumer Policy. Johns Hopkins University Press for Resources for the Future, Baltimore.

Bohm, P., and C. Russell, 1985. Comparative analysis of alternative policy instruments. In Kneese, A. V., and J. L. Sweeney (eds.), Handbook of Natural Resource and Energy Economics, Vol. 1. Elsevier Science Publishers, B.V., New York, pp. 395-460.

Botnick, D., 1983. Investigate previous dishonesty before bonding employees. Merchandising, **8**: 93-96.

Buchanan, P., and G. Tullock, 1975. Polluter's profits and political response. American Economic Review, 65: 139-147.

Cabe, R., and J. Herriges, 1992. The regulation of non-point sources of pollution under imperfect and asymmetric information. The Journal of Environmental Economics and Management, forthcoming.

Calvo, G., and S. Wellisz, 1979. Hierarchy, ability, and income distribution. Journal of Political Economy, **87**: 991-1010.

Carmichael, L., 1985. Can unemployment be voluntary?: comment. American Economic Review, **75**: 1213-14.

Carmichael, L., 1989. Self-enforcing contracts, shirking, and life cycle incentives. The Journal of Economic Perspectives, **3**(4): 65-83.

Chesters, G., and L. Schierow, 1985. A primer on nonpoint source pollution. Journal of Soil and Water Conservation, **40**(1): 9-13.

Clark, E., J. Havercamp, and W. Chapman, 1985. Eroding Soil: The Off-Farm Impacts. The Conservation Foundation, Washington, D.C.

Cooter, R., and T. Ulen, 1988. Law and Economics. Scott, Foresman and Co, Glenview, IL.

Costanza, R. and C. Perrings, 1990. A flexible assurance bonding system for improved environmental management. Ecological Economics, **2**: 57-55.

Dendy, F. E., 1968. Sedimentation in the nation's reservoirs. Journal of Soil and Water Conservation, **23**(4): 135-7.

Dickens, W., L. Katz, K. Lang, and L. Summers, 1989. Employee crime and the monitoring puzzle. Journal of Labor Economics **7**: 331-347.

Downing, Paul B., 1984. Environmental economics and policy. Little, Brown Company, Boston.

Eaton, B. and W. White, 1982. Agent compensation and the limits of bonding. Economic Inquiry, **20**: 330-343.

Faron, R., 1985. The pollution liability dilemma. Risk Management, **32**: 20-26.

Harl, N., 1986. The people and the institutions: an economic assessment. In Increasing Understanding of Public Problems and Policies - 1986. Farm Foundation, Oak Brook, Illinois.

Johnson, J., R. Prescott, D. Banker, and M. Morehart, 1986. Financial characteristics of U. S. farms. Agricultural Information Bulletin No. 500, U. S. Department of Agriculture, Economic Research Service, Washington, D. C.

Kambhu, J., 1990. Direct controls and incentive regulation. Journal of Environmental Economics and Management, **18**: S-72-85.

Kennedy, J., and J. Visser, 1990. An Introduction to U.S. Agricultural Programs: Agricultural Policies in a New Decade (K. Allen, ed.). Resources for the Future, Washington D. C. pp. 27-46.

Kerkvliet, J., and J. Shogren, 1992, The effect of environmental regulation on coal procurement strategies: design coal and multi-attribute quality. Journal of Environmental Management, forthcoming.

Klein, B. and K. Leffler, 1981. The role of market forces in assuring contractual performance. Journal of Political Economy, **89**: 615-641.

Kolm, S., 1973. A note on optimum tax evasion. Journal of Public Economics **2**(July): 265-70.

Lazear, E., 1979. Why is there mandatory retirement? Journal of Political Economy, **87**: 1261-1284.

Lazear, E., 1981. Agency, earning profiles, productivity, and hours restriction. American Economic Review, **71**: 606-620.

Lazear, E. and S. Rosen, 1981. Rank-order tournaments as optimum labor contracts. Journal of Political Economy, **89**: 841-864.

Leibenstein, H., 1957. The theory of underemployment in densely populated backward areas. Economic Backwardness and Economic Growth, Chapter 6, John Wiley & Sons.

Lindbeck, A. and D. Snower, 1988. The Insider-Outsider Theory of Employment and Unemployment. MIT Press, Cambridge.

Malcomson, James M., 1984. Work incentives, hierarchy, and internal labor markets. Journal Political Economy, 92: 486-507.

Mills, Edwin. S, 1972. Urban Economics. Scott, Foresman, and Company, Glenview, Ill.

Niskanen, W., 1971. Bureaucracy and Representative Government. Aldine, Chicago.

Parsons, D., 1986. The employment relationship: job attachment, work effort, and the nature of contracts. In Ashenfelter, O., and R. Layard (eds.), Handbook of Labor Economics, Volume 2. Elsevier Science Publishers, B.V., New York.

Perrings, C., 1989. Environmental bonds and environmental research in innovative activities. Ecological Economics, **1**: 95-110.

Phipps, T. and P. Crosson, 1986, Agriculture and the environment - an overview. In Phipps, T., T. Tim, P. Crosson, and K. Price (eds.), Agriculture and the Environment. Resources for the Future, Washington, D.C., 3-29.

Posner, R., 1986. Economic Analysis of Law (3rd ed.). Little, Brown, and Co., Boston.

Quigley, J., 1966, Water quality and agriculture in the United States - an overall view. In Brady, N. (ed.), Agriculture and the Quality of Our Environment: A Symposium Presented at the 133rd Meeting of the American Association for the Advancement of Science. AAAS Publication 85, Plimpton Press, Norwood, 129-135.

Reichelderfer, K. and M. Hinkle, 1989. The Evolution of Pesticide Policy. Environmental Interests and Agriculture, Political Economy of U. S. Agriculture: Challenge for the 1990's. (C. Kramer, ed.) Resources for the Future, Washington D.C., 27-46.

Rich, B., 1985. Environmental litigation and the insurance dilemma. Risk Management, **32**: 34-41.

Salop, S., 1979. A model of natural rate of unemployment. American Economic Review, **69**:117-125.

Shapiro, C. and J. Stiglitz, 1984. Equilibrium unemployment as a worker discipline device. American Economic Review, **74**: 433-444.

Solow, R., 1971. The economists approach to pollution and its control. Science 173 (August 6): 502.

Tietenberg, T., 1989. Indivisible toxic torts: the economics of joint and several liability. Land Economics, **65**: 305-319.

U.S. Department of Agriculture, 1985. Pesticide Assessment of Field Corn and Soybeans: Corn Belt States. Economic Research Service, Washington D. C.

U.S. Department of Agriculture, 1986. Economic Indicators of Farm Sector: State Financial Summary-1984. Economic Research Service, Washington, D. C.

Wegman, L., 1991. Air toxics: the strategy. The EPA Journal, **17**(1): 32-33.

Weiss, A., 1990. Efficiency wages - models of unemployment, layoffs, and wage dispersion. Princeton University Press, Princeton.

Xepapadeas, A., 1991. Environmental policy under imperfect information: incentives and moral hazard. Journal of Environmental Economics and Management, **20**: 113-126.

Yandle, B., 1988. Environmental policy: a perspective for the next decade. MAPI Policy Review PR-105 (MAPI, Washington, D.C.).

Yellen, J., 1984. Efficiency wage models of unemployment. AEA Papers and Proceedings, **74**: 200-205.

Young, R., and G. Horner, 1986. Irrigated agriculture and mineralized water. In Phipps, T., T. Tim, P. Crosson, and K. Price (eds), Agriculture and the Environment. Resources for the Future, Washington, D.C., 3-29.